OIL AND GAS OF THE RUSSIAN ARCTIC: HISTORY OF DEVELOPMENT IN THE 20TH CENTURY, RESOURCES, AND STRATEGY FOR THE 21ST CENTURY

Today, Russia is one of the three world leaders in the production of hydrocarbons: in 2014, our country produced 525 million tons of oil and 668 billion m³ of natural gas. At the same time, more than 90% of our gas and 10% of oil comes from the deposits in the Russian sector of the Arctic, i.e., the Arctic regions of Russia. It is only natural, therefore, that our country has been a historic leader in the multi-area development of the Arctic oil and gas resources—from prospecting to commissioning new oil and gas fields. In so doing, we have relied on domestic science and technology.

Pobeda oil field on the Kara Sea shelf.
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By the Russian sector of the Arctic, the author means the Arctic regions of Russia and the waters of the Arctic Ocean under the jurisdiction of Russia

Key words: Arctic shelf, oil, gas, history, prognosis

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Among the many awards bestowed on Kontorovich are the Order of the Red Banner of Labor, order “For Service to the Fatherland” of the III and IV degree, Order of Merit, medal “For Development of Mineral Resources and Development of the West Siberian Oil and Gas Complex,” etc. He was awarded the titles of the Honored Geologist of the Russian Federation, Honored Worker of the Oil Industry, and Honored Worker of the Gas Industry.
Kontorovich is the winner of the Global Energy International Prize (2009), the State Prize of Russia (1994), the Russian Government Prize (2002), laureate of A.N. Kosygin (2003) and N.K. Baibakov (2007) awards, was awarded the Triumph prize (2005), Demidov Prize (2005), I.M. Gubkin Prize, and M.A. Lavrent’ev Prize (2013), etc. Kontorovich is the author and coauthor of more than 900 scientific publications, has registered 4 inventions, and has been granted 3 patents.
Kontorovich has made an important contribution to the theory of oil and gas genesis; in cooperation with the RAS members A.A Trofimuk, V.S. Surkov, and other scientists, he worked out the theoretical and practical foundations for the prediction and discovery of the hydrocarbon potential in the Precambrian reservoirs of East Siberia. He has contributed greatly to the exploration and development of the major oil and gas provinces of Russia: Zapadno-Sibirskaya, Lena-Tunguska, and Khatanga-Vilyui. In the 1970–1980s, Kontorovich participated in the development of comprehensive programs for the exploration and prospecting of the oil and gas provinces in West and East Siberia and Yakutia. He is one of the authors of *Energy Strategy of Russia and Strategy for the Economic Development of Siberia*.
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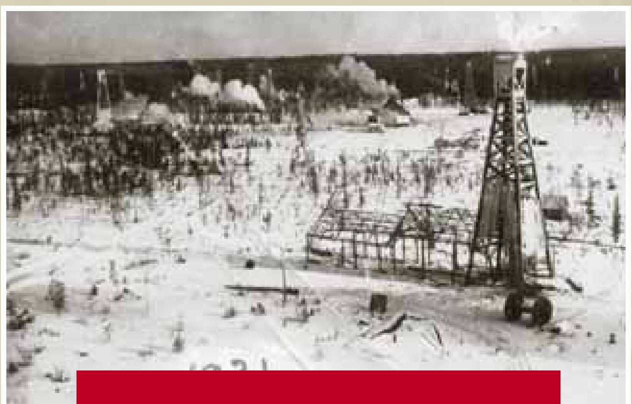
Oil and gas prospecting in the continental sector of the Russian Arctic began as early as in the 1930s. At that time, no other Arctic nation was engaged in hydrocarbon exploration in this region.

In the years before World War II and during the war, Soviet geologists contributed greatly to the development and prognosis of oil and gas resources in the Arctic territories of the Soviet Union. Here we can mention N.A. Gedroits, T.K. Emelyantsev, A.Ya. Krems, N.N. Rostovtsev, G.E. Ryabukhin, V.N. Saks, I.N. Strizhov, N.N. Tikhonovich, and other outstanding researchers.

Development of oil and gas resources: history and main lessons

In 1930, the world’s first oil field in the Arctic—Chibyuskoe—was discovered in the Republic of Komi. Its development started in the same year. Two years later, in 1932, geologists discovered the large Yarega oil field, which was put into development in 1935.

Thus, the Soviet Union became the world’s first country to begin the prospecting, exploration, and development of



Doctor N. A. Viktorov and driller A. M. Romanenko on the creek Chibyu, August 20, 1929,

A. M. Romanenko's expedition to the Chut river.
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In 1930, the world's first oil field in the Arctic—Chibyuskoe—was discovered in the Republic of Komi. *Photo:* A panorama of Chibyu, 1931.
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THE FIRST OIL FROM THE NORTH

Exploration of oil fields in the Ukhta region of Pechora krai began in the early 1910s. In 1915, the Russian partnership Neft (Oil) drilled the first exploration and production well, which struck oil. These plans, however, were abandoned because of World War I.

The development of oil and gas resources of the Pechora krai was resumed only 14 years later, with the start of intensive industrialization. Then, the main problem was the shortage of labor force, which was being solved by creating the OGPU (Joint State Political Directorate) labor camps. By 1928–1929, the penitentiary and corrective labor system, which held twice as many prisoners as they could accommodate, was in need of urgent reform. Therefore, the People's Commissariat of Justice approached the government with a proposal to use prison labor through the creation of concentration camps in the north of the European part of the Soviet Union.

In early summer of 1929, a special agency SEVLON (Northern Special Purpose Camp) was formed within the OGPU, and in August the first OGP expedition of 139 people, which included a large group of prisoners and carried heavy equipment, was sent to a place near the Ukhta river, where oil development had been started before the revolution.

As early as in September and October, the expedition noticed oil seeps and began to explore the possibility of industrial oil production. According to the memoirs of the engineer R. L. Zombe, "Drilling work began in September with the construction of the tower for craelius core drilling, then after some geological work the site of its emplacement was determined. The tower builders lacked experience and the construction works took more than a month but after Ya. M. Moroz, the Head of the Ukhta Expedition, with his inherent bolshevist perseverance, able leadership, and inexhaustible energy, arrived in Ukhta, preparatory works were soon completed and well no. 1 was drilled on October 29, 1929." In 1929, the first oil production at Ukhta was 5 tons.

At the end of November 1929, a new exploration and production well no. 5 was staked, the drilling of which began in the spring of the next year; and on October 25, 1930, light oil flew to the surface under natural pressure with the flow rate exceeding 4 tons a day. This confirmed the Chibyuskoe industrial field of Devonian oil and was the actual birthday of the oil and gas industry of the modern Republic of Komi.

From materials collected by L. G. Borozinets "OGPU Ukhta expedition of 1929" // Historical and Cultural Atlas, Ukhta. Central Library Municipal Organization of the Urban District "Ukhta", 20155

the Arctic oil fields. The Yarega oil field is a pioneer not only in oil production but also in other aspects. Its oil is heavy (with a density of 945 kg/m^3) and viscous. The reservoir temperature is 6—8 °C. It was one of the first fields of hard-to-recover oil to be developed and the first site to test and apply the technologies of heavy oil processing (1939) and thermal heavy oil recovery (1972).

On June 22, 1936, the USSR Council of People's Commissars (CPC) adopted a decree on the establishment of the Chief Directorate of the Northern Sea Route (Glavsevmorput) under the CPC. According to the CPC Resolution, Glavsevmorput was to complete the development of the Northern Sea Route from the Barents Sea to the Bering Strait; organize sea, river, and air transportation services, telecommunications, and research work in the Soviet Arctic; develop production facilities and explore the natural resources of the Far North; and promote the economic and cultural progress of the indigenous population of the Far North and involve them in the building of socialism.

It was established that Glavsevmorput would be in charge of all the islands and seas of the Arctic Ocean in the European part of the Soviet Union and the territory north

Gas processing plant no. 5 at the Yamburg field, which was put into operation in January 1988.
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Gas processing plant at the Yamburg field, 2007.
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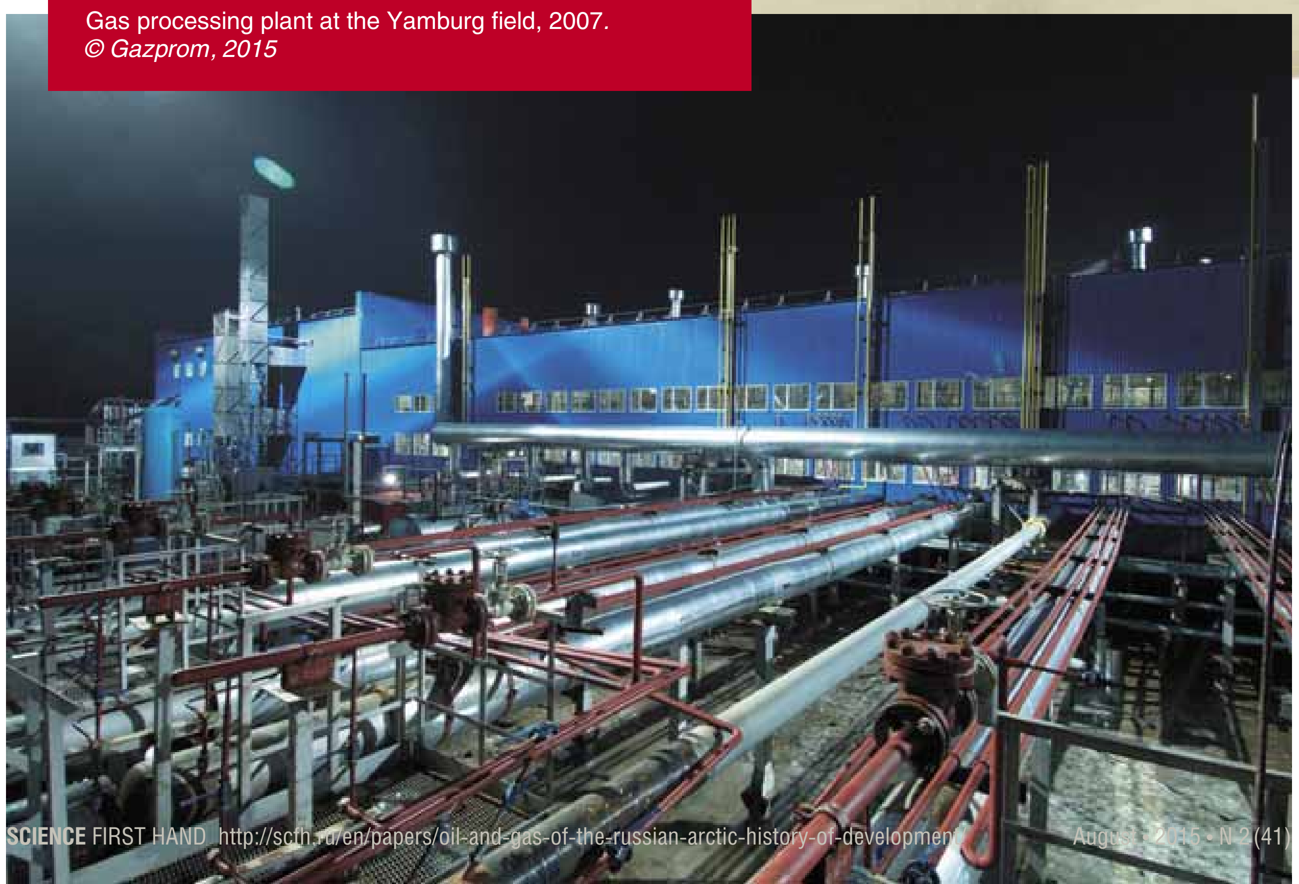

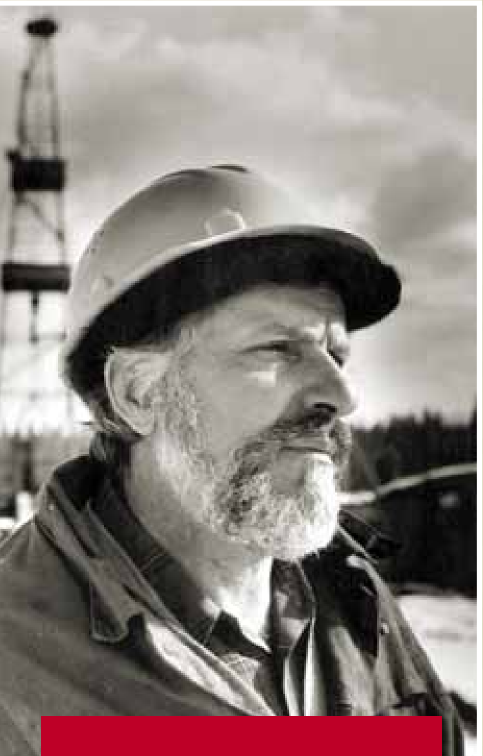

Vyktulskoe field.
Above: the drilling foreman Glinski.
Below: laying the underground communications to Pumping/Heating Station of the head facilities
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of the 62nd parallel in the Asian part of the Soviet Union. The first head of Glavsevmorput was Otto Schmidt, a famous Arctic explorer and a member of the USSR Academy of Sciences.

Glavsevmorput was responsible, in particular, for the organization of geological surveys, prospecting, and exploration of mineral resources. This agency was also in charge of the enterprises that were set up to extract these resources. To this end, a special Geological and Mining Department was established within Glavsevmorput.

In the mid-1930s, Soviet geologists began to search for oil in the eastern regions of the Soviet Arctic, i.e., in the north of Siberia. In 1935, the Nordwick expedition (Emelyantsev) described the surface oil seeps in the Nordwick region on the coast of the Laptev Sea. In 1936, the Ust'-Yenisei expedition, which was organized by the Geological and Mining Department (Nikolai Gedroits), discovered methane seeps in the lower reaches of the Yenisei River. The works in the Yenisei region continued even during World War II. In 1942, the first flow of gas and then oil was pumped from Well 13-R at the Malokhet arch in the lower reaches of the Yenisei river. In 1944, the first oil was pumped from Well 102-R. During the war, Vladimir Saks was in charge of geological surveys in the Arctic regions of West Siberia. In 1945, he recommended the lower reaches of the Nadym River as one of the priority areas for hydrocarbon prospecting.

Immediately after the end of World War II, our geologists continued to explore the hydrocarbon prospects of the Soviet Arctic. In 1948, the Research Institute of Arctic Geology (RIAG) was established in Leningrad. This institute played a key role in geology studies, including into the prospects of hydrocarbon and ore production in the Arctic regions. In 1950, Novosibirsk and Tomsk geologists (V.A. Nikolaev from the Institute of Mining and Geology, West Siberian Branch, USSR Academy of Sciences, V.S. Shatsky from the West Siberian Geology Administration, and others) were commissioned to perform a geological survey in the north of West Siberia. This marked the beginning of a large-scale campaign to explore the territory of the Yamal–Nenets Autonomous Okrug (YaNAO). In the mid-1950s, N.N. Rostovtsev theoretically predicted the discovery of giant gas fields in the north of West Siberia.

Intensive development of the Arctic oil and gas resources began in the 1960s. In 1960–1980s, geological explorations in the Arctic regions were guided by brilliant Soviet scientists and organizers of research and prospecting works—A.V. Sidorenko, E.A. Kozlovsky, L.I. Rovnin, N.N. Rostovtsev, F.K. Salmanov, Yu.G. Erv'e, I.S. Gramberg, A.Ya. Krems, I.I. Nesterov, V.V. Semenovich, A.A. Trofimuk, V.V. Fedynsky, A.M. Brekhuntsov, B.Ya. Vasserman, G.P. Bystrov, V.L. Ivanov, M.K. Kalinko, N.Kh. Kulakhmetov, V.D. Nakoryakov, V.T. Podshebyakin, Yu.A. Rossikhin, D.B. Tal'virsky, L.K. Teplov, E.A. Teplyakov, A.F. Titov, R.V. Trebs, D.S. Sorokov, F.Z. Khafizov, V.I. Shpil'man, L.G. Tsibulin, A.G. Yudin, and many others.

I feel proud to have been involved in these works at all stages.

In the 1960s–1970s, geological prospecting concentrated in the recently discovered giant West Siberian oil and gas province. In 1962, the first gas field—Tazovskoe—was discovered in the YaNAO, i.e., in the Arctic part of the West Siberian oil and gas province. This event was followed by the discovery of new fields: the large Novoportovskoe oil and gas condensate field (1964), the large Gubkinskoe oil and gas condensate field and the unique Zapolyarnoe gas field (1965), the unique Urengoy oil and gas condensate field (1966), the unique Medvezhye gas field (1967), the Arctic gas field and Russkoe oil field (1968), and the unique Yamburg field (1969). Before the discoveries in West Siberia, the world had not known such gigantic gas fields.

The 1970s were the time of discoveries on the Yamal peninsular: the unique Bovanenkovskoe gas field (1971), Kharasavey and South Tambey fields (1974), and the Rostovtsev oil and gas field (1986).

In the 1980s–1990s, oil and gas fields were discovered in the northeast of the West Siberian oil and gas province, i.e., in the lower reaches of the Yenisei river in the Krasnoyarsk krai—the unique Vankor field and the large Tagul, Lodochnoe, and Suzun fields.

In the Timan-Pechora oil and gas province (Republic of Komi), geologists discovered the large oil and gas condensate field Vuktyl (1964) and the large oil fields Usinsk (1963) and Vozeiskoe (1972).

In the 1970s–1980s, major fields were discovered even farther to the north, in the Nenets Autonomous Okrug (NAO, Arkhangelsk oblast): Kharyaga (1970), Naul (1979), Yuzhno-Khylchuyuskoe (1981), Toboi-Myadsei (1984), Trebs (1987), Titov (1989), etc. A total of twenty large and medium-sized fields were found in the NAO, the Kharyaga,

The giant Bovanenkovskoe oil and gas condensate field on the Yamal peninsula.
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Trebs, and Toboi-Myadsei being the largest ones.

In the early 1980s, deep-hole prospecting was launched in the western sector of the Russian Arctic (Barents and Kara Seas). The first wells were drilled on the Arctic islands, and one of them was an immediate success. In 1982, the Peschanoozernoe field was discovered on the Kolguev island with large reserves of oil and wet gas. Its pilot operation began two years later, in 1985.

Then, prospecting works were continued in the Barents and Kara Seas. As early as in the mid-1980s, three fields were discovered—Murmanskoe, Severo-Kildinskoe, and Pomorskoe. In the second half of the 1980s, four more fields were found, including two unique gas fields (Shtokmanskoe and Rusanovskoe) and two oil fields (Severo-Gulyaevskoe and Prirazlomnoe). In the 1990s, eight more deposits were discovered, one of which (Leningrad) was unique and six were large. The total reserves of these deposits exceed 10 trillion m^3 of gas and 0.5 billion tons of oil. Recently, the Rosneft company announced the discovery of another giant field in the Kara Sea. The oil field was named *Pobeda* (Victory), which is a sacred word for every Russian citizen. Today, more than 90% of gas reserves and more than 45% of oil reserves on the shelves of the Earth's circumpolar belt are concentrated on Russia's West Arctic shelf in the seas of the Arctic Ocean.

Currently, the YaNAO, the north of the West Siberian oil and gas province, is the world's largest gas producing region and a major center of oil production.

The huge volumes of oil and, especially, gas production in the Arctic over the last four decades create an illusion that it has always been like this. My peers belonging to the generation that performed this miracle know well what was behind the discovery, prospecting, and exploitation of these fields, the development of the transport infrastructure and equipment for the prospecting, discovery, and exploitation of oil deposits, and the creation of comfortable living conditions for the explorers of mineral resources in the Russian North. All this was a result of the huge, unique, and, it will be no overstating to say, heroic effort of several generations of researchers from the USSR Academy of Sciences, colleges and universities, sectoral institutes of the USSR Ministry of Geology, USSR Ministries of Oil and Gas Industry, and many other ministries and departments, engineers, workers, physicians, and educators. The grand task of predicting, providing a scientific substantiation for the prospecting areas, developing the technologies of prospecting, developing the unique gas fields, creating the transport infrastructure, and working out construction technologies suitable for the harsh and inclement natural and climatic conditions of the Arctic was accomplished by relying solely on the national research, engineering, and industrial resources and national technology and instruments. It was

The Prirazlomnoe field.
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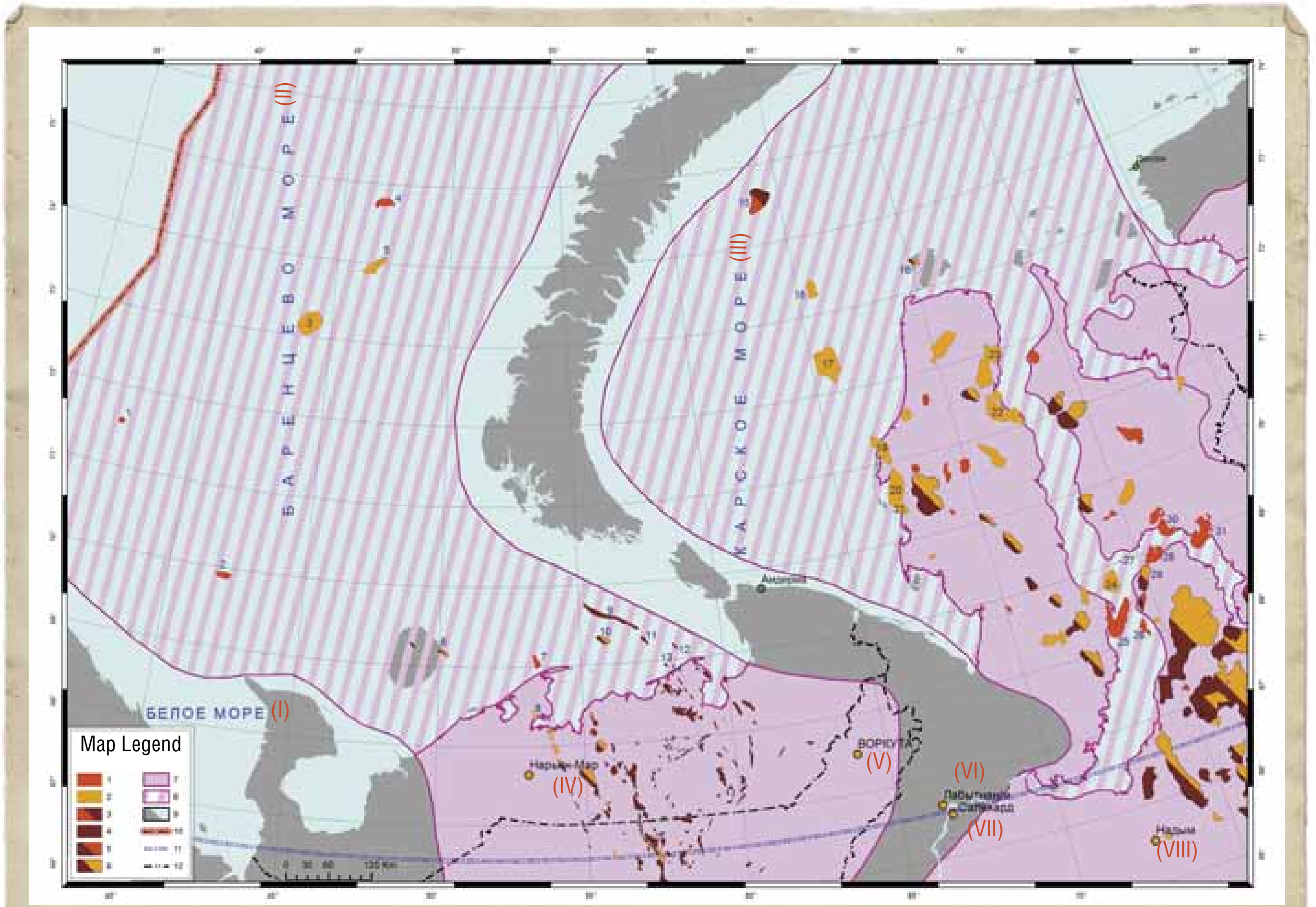


Oil and gas fields on the shelf of the Barents and Kara Seas. Fields: 1 – gas (g), 2 – gas condensate (gc), 3 – gas-oil (go), 4 – oil (o), 5 – oil-and-gas (og), and 6 – oil and gas condensate (ogc). Projected fields: 7 – onshore areas, 8 – offshore areas, and 9 – unpromising onshore areas and offshore areas. Borders: 10 – state borders, 11 – the Arctic Circle's border, and 12 – borders of federal subjects of Russia. Geographical names: I – White Sea, II – Barents Sea, III – Kara Sea, IV – Naryan-Mar, V – Vorkuta, VI – Labytnangi, VII – Salekhard, and VIII – Nadym

List of deposits

No.	Hydrocarbon deposits	Type
1	Severo-Kildinskoe	g
2	Murmanskoe	g
3	Shtokmanskoe	gc
4	Ludlovskoe	g
5	Ledovoe	gc
6	Peschanoozerskoe	ogc
7	Pomorskoe	g
8	Korovinskoe	gc
9	Dolginskoe	o
10	Severo-Gulyaevskoe	ogc
11	Prirazlomnoe	o
12	Medyn-More	o
13	Varandey-More-1	o
14	Varandey	o
15	Pobeda (Universitetskoe)	go
16	Rusanovskoe	gc
17	Leningradskoe	gc
18	Beloostrovskoe	ogc
19	Kharasavey	gc
20	Kruzenshternskoe	gc
21	Yuzhno-Kruzenshternskoe	g
22	Yuzhno-Tambeiskoe	gc
23	Tasiiskoe	gc
24	Severo-Kamenomysskoe	gc
25	Kamenomysskoe	g
26	Obskoe	g
27	Chugor'yakhiskoe	g
28	Semakovskoe	g
29	Severo-parusovoe	ogc
30	Tota-Yakhinskoe	g
31	Antipayutinskoe	g

a completely new experience and new level of forecasting, exploration, prospecting, and discovery of gas fields in the world practice.

After the end of World War II, in 1946, oil prospecting was initiated in the Arctic regions of the United States, in Alaska. The first small deposits were discovered onshore at the turn of the 1940s and 1950s—the Barrow gas field in 1949 and the Umiat oil field in 1950. In 1967, a unique oil and gas field Prudhoe Bay was discovered in this region, and in 1969, another large field called Kuparuk River Unit. In1965, the Point Thomson oil and gas field was discovered and suspended without exploration. The field was explored only in 1977 and proved to be a giant. Its reserves were 3 trln. m^3 of gas and 400 mln. tons of oil. The first offshore field Gwydir Bay on the northern shelf of Alaska was discovered in 1969. The largest offshore fields on this shelf are Endicott (80 mln. tons) and Point McIntyre (83 mln. tons oil and 17 bln. m^3 of gas).

Oil production at the Prudhoe Bay field was launched in 1977; the maximum production—83 million tons—was achieved in 1987. The oil is transported via the 1290-km Trans-Alaska Pipeline System to the port of Valdez in the south of Alaska. The pipeline was put into operation in 1977. Oil production on the shelf began in the Endicott field in 1987; at present nine fields are being developed. At the end of 2014, the cumulative oil production in the continental and sea parts of the basin amounted to about 2.5 bln. tons.

Gas production in the Arctic part of Alaska for local needs was launched in 1950. The unique Point Thomson gas field has not been developed yet, and the decision has not been made on the construction of a pipeline.

These data show that despite the undoubted accomplishments of American geologists, geophysicists, and developers of oil fields in the Arctic, they cannot be compared with the achievements of the Soviet Union and Russia in the Arctic regions of the West Siberian and Timan-Pechora oil and gas provinces, or on the shelves of the Barents and Kara Seas.

The Pobeda field in the Kara Sea.
© Rosneft, 2015

Russia is a leader in many areas of hydrocarbon resources development in the Arctic. The Soviet Union/Russia was the first to discover hydrocarbons in the Arctic; this country has created unique technologies, explored the deposits, launched their development, and designed and built giant transport systems that have no analogues in the world. Especially impressive are our achievements in the development of the unique Arctic gas fields of West Siberia (Medvezhye, Urengoy, Yamburg, Zapolyarnoe, and Bovanenkovskoe). Neither the United States nor other Arctic countries have any comparable experience in exploring such gas phenomena.

The Soviet Union/Russia has always been the first in prospecting, exploration, and commissioning oil and gas fields when it relied on the national science, technology, industry, and, therefore, on the domestic labor.

Now, when we are experiencing another round of anti-Russian sanctions, which appear to terrify some of our economy and business leaders as well as mass media, we must be especially proud of the experience and heroic deeds of our predecessors: scientists, university professors, and engineers who are still working in our field. I believe this is the reason why on the eve of the 70th anniversary of the

Onshore areas, offshore areas	Initial recoverable resources of oil, condensate, and associated gas and geological resources of free gas				
	Oil, billion tons	Associated gas, billion m^3	Free gas, trillion m^3	Condensate, million tons	Total HCR, billion tons
Onshore areas	51.2*	2876.0	94.6	1378.0	150.1
Offshore areas	19.4	52553.8	107.6	6325.2	135.7
Total	70.6*	5429.8	202.2	7703.2	286.0

Hydrocarbon resources of onshore and offshore areas of the Russian Arctic.
** without the resources of the Bazhenov formation*

end of Worl War II, Rosneft named the new field in the Kara Sea *Pobeda* (victory).

Oil, natural gas, and condensate resources in the Russian sector of the Arctic

Today, it is recognized worldwide that the Russian Arctic is fabulously rich in oil and gas, both onshore and offshore in the seas of the Arctic Ocean. Acknowledging this fact is a result of the creative efforts of our outstanding researchers in the field of geology over the last three decades of the twentieth century. The All-Russian Research Institute for Geology and Mineral Resources of the Ocean (formerly, the RIAG) has carried out large-scale investigations into hydrocarbon geology and potential of the Earth's circumpolar region for nearly 70 years. The first researchers to make and confirm predictions about the unique oil and gas resources on the shelf of Russia's Arctic seas were Academicians A.A. Trofimuk and I.S. Gramberg, and their research teams and schools.

Gramberg created a coherent concept for the evolution of the oceans and oil-and-gas-bearing sedimentary basins in their border regions, which has been the foundation for the assessment of the hydrocarbon bearing prospects for the offshore areas of the Arctic Ocean. He guided and directly participated in the first assessments for the onshore and offshore hydrocarbon resources in the Russian sector of the Arctic and in the seas of the Arctic Ocean.

Over the last quarter of the 20th century, the Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch, Russian Academy of Sciences (IPGG SB RAS) conducted ongoing geology studies and generalized geological and geophysical materials on the oil and gas geology in the onshore and offshore territories of the Russian Arctic. The investigations were carried out using the entire arsenal of geological methods—biostratigraphic, lithological, petrophysical, geochemical, and geological oil and gas methods—employing state-of-the-art instruments and technology. The institute has assembled a unique bank of geological and geophysical data on the Arctic territories and water areas, carried out a tremendous analytical work, and made a core repository and a unique collection of oils.

The studies allowed RAS scientists (IPGG SB RAS, RAS Institute of Oil and Gas Problems (IOGP RAS), and SB RAS Institute of Oil and Gas Problems (IOGP SB RAS)), Moscow State University (MSU), sectoral research institutes, and prospecting organizations of the Russian Ministry of Natural Resources (All-Russian Research Institute for Geology and Mineral Resources of the Ocean (ARIGMRO), All-Russian Research Institute for Petroleum Exploration (ARIPE), etc.), OAO Gazprom, OAO Gazprom Neft, OAO Rosneft, and OAO Novatek to construct up-to-date models describing the geological structure of sedimentary basins throughout all the onshore and offshore areas of the Russian Arctic and provide and continuously update quantitative estimates for the hydrocarbon bearing prospects.

It is important to mention the series of works by RAS Academicians I.S. Gramberg, N.L. Dobretsov, N.P. Laverov, V.E. Khain, RAS Corresponding Members E.V. Artyushkov, N.A. Bogdanov, V.A. Vernikovsky, L.I. Lobkovsky, Doctors of Geology and Mineralogy E.V. Shipilov, N.Yu. Matushkin, D.V. Metelkin, and others devoted to the reconstruction of the geological history of the Earth's Arctic sector in the past billion years. These studies lay the geodynamic foundation for assessing the hydrocarbon bearing prospects of the Arctic, including in the water area of the Arctic Ocean. At the same time, they will play an important role in the international legal justification of the outer border of Russia's continental shelf in the Arctic Ocean.

The table presents a summary of the hydrocarbon bearing prospects of the Russian Arctic land and water areas provided by specialists from the IPGG SB RAS, ARIGMRO, ARIPG, ARIPE, MSU, and IOGP SB RAS. The table shows that according to the forecast, the initial onshore oil resources of the Arctic territories are higher than the offshore reserves. The onshore and offshore gas resources differ only slightly. One must bear in mind that there is little geological and geophysical background data on the water areas of the Russian east. Therefore, the above estimates will be more accurate when new information resources are available. In particular, the future estimates for the oil resources in the Russian water areas of the Arctic Ocean might well be considerably higher. According to the existing estimates, more than a half of the offshore hydrocarbon resources are concentrated in the western part of the Russian Arctic, in the Barents and Kara Seas. In any case, it is clear that the oil and gas resources of the circumpolar Arctic basin and its Russian sector are comparable with the unique oil-and-gas-bearing basins of the Middle East and West Siberia.

Priority areas for hydrocarbon prospecting, exploration, and production in the Arctic

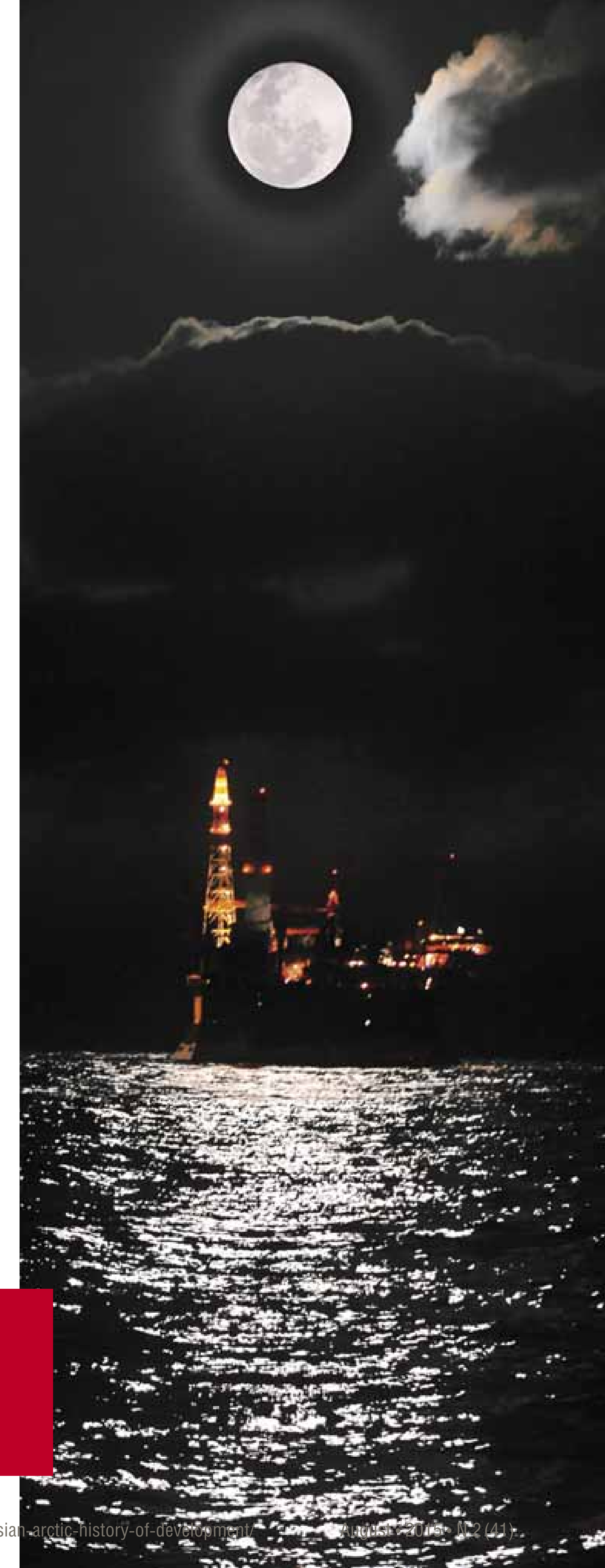
In the coming years, the Russian sector of the Arctic will continue to play a leading role in gas production and an increasingly important role in oil production.

Without doubt, the YaNAO will continue to be Russia's main base of gas production, which will be shifting to the Yamal peninsula (the Bovanenkovskoe field and, in the longer run, the Kharasavey field, the Tambey group, etc). The Nadym-Pursk region of the YaNAO will play an increasing role in wet gas extraction.

In view of the growing competition between gas suppliers in the world market, there is a need to develop and exploit new gas regions—with a thorough assessment of all possible risks.

Taking into account the declining production in "mature" regions, the oil output in the Arkhangelsk oblast, north of West Siberia, YaNAO, and Krasnoyarsk krai should increase as these regions already have a developed resource base.

Given a reasonable demand for oil and proper investment, oil production in the Arkhangelsk oblast can reach 22–25 million tons per year.



The Prirazlomnoe field. Today, it is the only oil field in the Russian Arctic with offshore extraction.
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In the Republic of Komi, the oil company OAO Lukoil is planning to increase production at the region's oldest Yarega oil field. The field has been exploited for 80 years, and its total output exceeds 20 million tons. In different years, the long-term estimates for the oil output varied from 2–3 to 5–6 million tons per year. To transport the heavy viscous Yarega oil, the companies Transneft and Lukoil have completed the first construction stage of the 38-km Yarega-Ukhta pipeline. Its annual capacity is 1 million tons of oil. A new system of reservoir engineering is being tested, which is expected to bring the oil recovery rate up to 0.85. The construction volume of mine roadways at the field in the nearest two or three years will be grow by factor of 1.3, and the scope of drilling works will expand by a factor of 1.2.

In the Pechora Sea, Gazprom Neft has launched the development of the Prirazlomnaya field from a platform of the same name. In the future, the company is planning to develop the Dolginskoe field.

Below I identify the three main nodes of growth of new oil production centers in the north of the West Siberian oil and gas province.

The first should be formed along the route of the Zapolyarye-Purpe pipeline in the YaNAO. It is extremely important to complete the pipeline construction works, which are now being carried out effectively by Transneft. The commissioning of new fields along the route of the Zapolyarye-Purpe pipeline will enable an increase in the oil production in the YaNAO by 40–50 million tons. It is necessary to synchronize the pipeline construction and the development of oil fields along its route.

Special attention should be paid to the production, transportation, and processing of the heavy viscous oils from Cenomanian deposits (the Russkoe and other oil fields). These oils can be an excellent raw material for the production of Arctic oils and road bitumens, for balneological purposes, etc.

The second node should also be formed in the YaNAO and centered at the Novoportovskoe field. In the longer term, it can also include the Rostovtsev field.

Thee third node of growth already has a production base. It is the giant Vankor field in the northwest of the Krasnoyarsk krai, which has already been put into operation by Rosneft. It is necessary to expedite the completion of the prospecting and commissioning of the Tagul, Suzun, and Lodochnoe fields, which are located in the vicinity of the Vankor field. Then this region will provide a stable annual output of about 30 million tons oil.

The primary task of offshore prospecting in the seas of the Arctic Ocean must be regional explorations and comprehensive prospecting works. In the western regions of the Arctic shelf, where there are sufficient geophysical works, it is necessary to design and implement a program of parametric drilling.

On the shelf of the Arctic seas of the Eastern Siberia and Far East, geologists should complete the regional geophysical works and proceed to parametric drilling. The latter works have already been launched and consistently conducted by Rosneft. Gravity and magnetic surveys have already been carried out in the Chukchi Sea on an area of 440,000 km^2. There is a program of CDPM 2 seismic surveys in the East Siberian Sea to provide 10,000-km seismic survey profiles. In 2014, despite difficult ice conditions, researchers conducted 2,000 km of CDPM 2D seismic surveys accompanied by gravimetric, magnetometric, and geochemical studies along the profiles. Regional seismic surveys in the Laptev Sea have been initiated.

In some cases, it appears feasible to carry out prospecting and develop deposits on the Arctic shelf. The United States and Norway are now involved in these projects. Russia is beginning to implement them as well.

Since 2003, Novatek has been developing the large Yurkhar field on the Tazovsky peninsula. The western part of the field is located on land, but most of the field, i.e., its central and eastern parts, are in the Taz Bay. The field is being developed from the shore by drilling horizontal wells. At the Yurkhar site, there are 1 gas deposit, 19 gas-condensate deposits, and 3 oil and gas-condensate deposits. The current annual production at the field is a little more than 1 billion m^3. By 2016, gas production at the field will exceed 6 billion m^3 per year.

In 2014, Gazprom Neft launched the development of the Prirazlomnoe field in the Pechora Sea. Now the company is exploring the large Dolginskoe oil field, which is located 110 km from the mainland coast. The field was discovered in 1999. Since then, it has been a focus of extensive seismic and exploration surveys, including an 11,000-km 2D seismic survey and a 1,600 km^2 3D seismic survey and the drilling of three exploratory wells.

Russia will need the large offshore oil and gas reserves on the Arctic shelved to both satisfy the domestic demand and meet international obligations on global energy supply in the second half of the 21st century. Therefore, it is high time to prepare the resource and technological base. It is encouraging to note that Rosneft, Gazprom, Gazprom Neft, and Novatek are now efficiently working in all these directions.

OAO Lukoil has found innovative technological solutions and thus breathed a new life into the Arctic-Yarega oil field, one of the oldest in the oil industry.

The role of the Arctic in the development of oil and gas chemistry in Russia

Should we develop hydrocarbon processing in the Arctic, or should it only serve as a raw material base of the Russian and global power industry?

Russia has unique hydrocarbon resources for the development of oil and gas chemistry in the Arctic regions of Western Siberia. However, the country does not have large-scale systems for collection and transportation of the hydrocarbon gases C_2–C_4, and its oil and gas chemical production facilities are suboptimal in terms of raw materials (naphtha instead of hydrocarbon gases C_2–C_4) and have low capacity and insufficient output. As a result, a considerable portion of the raw materials is burnt, damaging the environment; and the country incurs huge economic losses and has to import petrochemicals. Here, it makes sense to recall Dmitry Mendeleev's wise words: "Oil is not fuel. You can just as well burn banknotes in your stove."

The YaNAO produces huge amounts of wet gas. However, due to the absence of facilities for wet gas processing or commercial transportation, the companies simply burn most valuable raw materials such ethane, propane, and

A gas production operator inspects the equipment. The Bovanenkovskoe field. April 2014. *© Gazprom 2015*

V. S. Surkov, a communist party official, and the Soviet researchers A. A. Trofimuk, A. M. Zoteev, G. S. Fradkin, and A. E. Kontorovich. *Tiksi, 1984*

Leading Siberian geologists at the Oleneksky bitumen field. *Arctic, Yakutia, 1984.*
Left to right: RAS Member A. A. Trofimuk; RAS Corresponding Members I. I. Nesterov, A. M. Zoteev, and G. S. Fradkin; RAS Members V. S. Surkov and V. F. Gorbachev, and A. E. Kontorovich; RAS Corresponding Members A. F. Safronov and S. S. Shatov

butanes. The annual losses of ethane, propane, and butane have been 10–11 million tons in recent years. Over the last 10–15 years, we have been burning extremely valuable raw materials, whose market price is tens or, perhaps, hundreds of billions of US dollars. This is a national tragedy. To think that amid this wastefulness, government agencies and the business community are constantly complaining about the slowing economic growth due to the lack of investment...

In this regard, I think it is appropriate to recall the words of the Russian President Vladimir Putin in his address to the Federal Assembly on December 4, 2014: "...Russia's development depends above all on the country's own efforts. We will only succeed if we ourselves earn our prosperity and affluence, rather than hope for an opening or a favorable situation on foreign markets. We will succeed if we defeat disorder, irresponsibility, and our habit of burying good decisions in red tape. I want everyone to understand that in today's world this is not simply an obstacle to Russia's development but a direct threat to its security."

The Trofimuk Institute of Petroleum Geology and Geophysics SB RAS has repeatedly raised these issues over the last 15–20 years; however, neither government agencies nor the business community gave heed to our words...

Therefore, it is imperative to take the following action as soon as possible:

- Impose a statutory ban on the extraction of wet gas in the YaNAO in the absence of adequate facilities for its processing and means of transportation for the derived products.
- Create production capacities in the YaNAO for processing 150–180 billion m^3 wet gas per year.
- Impose a ban (as is done in the United States for many kinds of raw materials) on exports of the hydrocarbon gases C_2–C_4.
- Create a system for the transportation of wet gas processing products (WLFH, ethane, and propane-butane fraction) to the regions with a developed petrochemical industry, i.e., to Bashkortostan, Tatarstan, and possibly to the northwest of Russia.
- Achieve a sharp increase in the pyrolysis production capacities in regions with a developed petrochemical industry.
- Complete the construction of the Novy Urengoy Gas and Chemical Complex and proceed to the design and implementation of the second stage of the complex.
- Revise and update the overall development program for the petrochemical industry.

The experience of the largest gas-producing nations (United States Canada, Qatar, Iran, Saudi Arabia, etc.) shows that it is expedient to locate gas-processing and petrochemical production facilities closer to the extraction sites. It is therefore necessary to devise and consistently implement a strategy for the diversification of the YaNAO economy.

Likewise, it is advisable to arrange on-site processing of heavy viscous oils.

It seems that the decision-making government agencies and business community still follow the wacky idea formulated in the "freewheeling" 1990s by some "economists" divorced from reality and believing that it was impossible to live or work in the Arctic. Life has refuted this view—compare the demographic indices in the YaNAO and central Russia...

Thanks to the raw materials available in the YaNAO, Russia is well placed to become a major manufacturer of petrochemicals and a stable supplier of these products to the domestic and, potentially, foreign markets. This is a direct path to the GDP growth and one of the main ways to overcome the stagnation of our economy and make a transition from the resource-based economy to economy of innovation. Government must invest in the real sector rather than in banks; in particular, it should promote the development of petrochemical industry. I would like to reiterate Putin's golden words: "Russia's development depends above all on the country's own efforts. We will only succeed if we ourselves earn our prosperity and affluence...!"

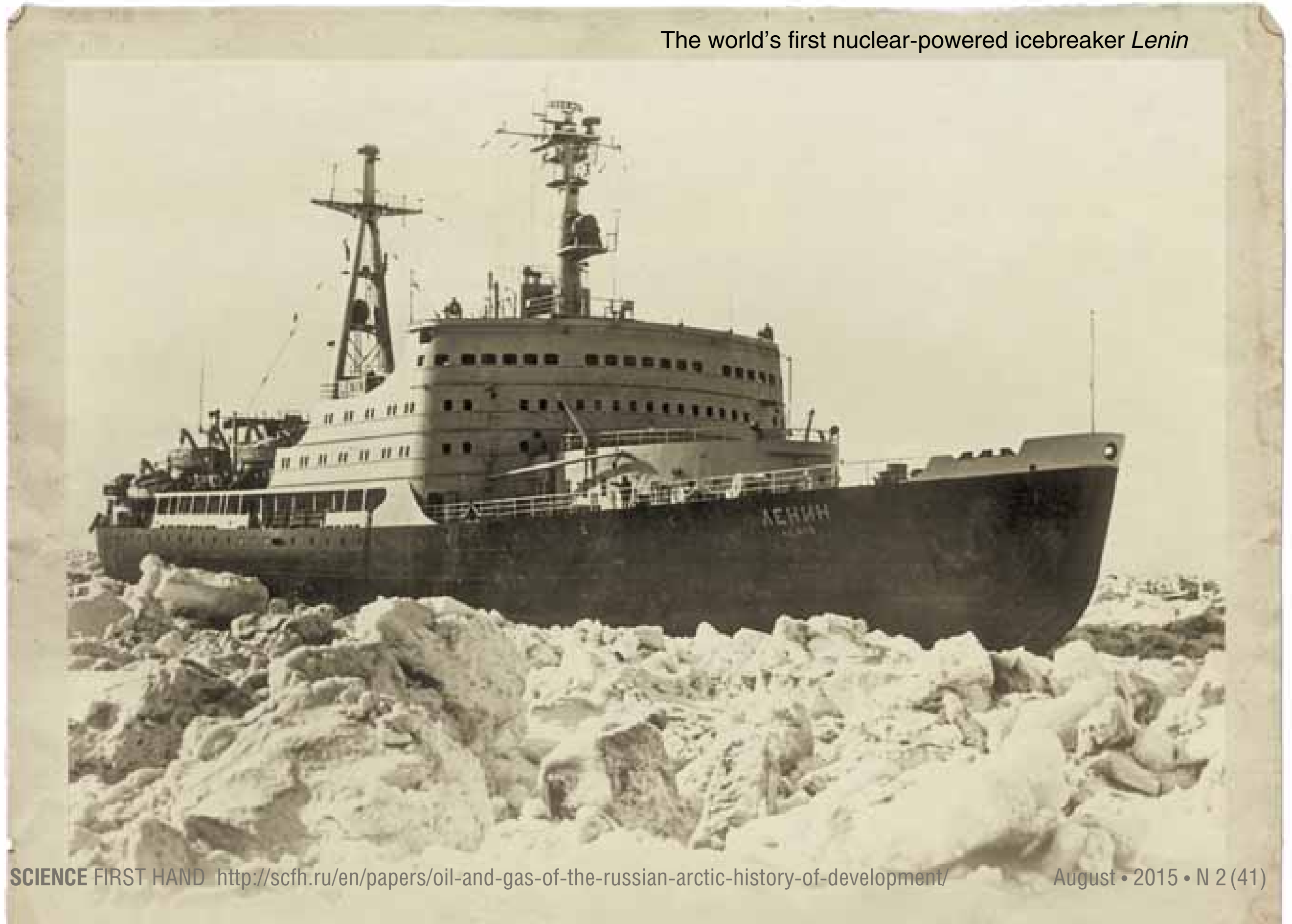
Note the admirable case of China: being an importer of raw materials, this country is developing petrochemical industries and making generous investment in this production to become the world's second petrochemical producer. The Chinese communists and Middle Eastern sheikhs know well how to diversify an economy based on unique materials and transform it from a petro-state into a land of innovation... Why are the leaders of our economy unable to understand that?! It seems upsetting and outrageous that enjoying such an excess of raw materials, Russia burns them out and, even in the long run, plans to export (the Khorda project) rather than process these resources. It is humiliating for Russia. We cannot allow this to continue.

Creating a new generation of technology, equipment, and catalysts for petrochemical industry is a direct responsibility and even a challenge for the Russian Academy of Sciences and its successor, the Federal Agency for Scientific Organizations.

Development of transport systems. The Northern Sea Route as a core of hydrocarbons logistics in the Russian Arctic

The economic development of Russia's Arctic regions raises the crucial issue of setting up transportation systems. In this regard, a major task is to restore the communications lost in the 1990s and the first years of the 21st century. The increasing deterioration of the communications is apparent even in such economically developed regions as the Arkhangelsk oblast, Republic of Komi, YaNAO, and the northwest of the Krasnoyarsk krai. This calls for the

The world's first nuclear-powered icebreaker *Lenin*



development and launching of a comprehensive national program for highway and railway construction.

In the Arctic, the transport system should be focused on the large-scale development of the Northern Sea Route and the construction of ports and beach landings all along the route.

The most advanced oil companies already pursue this path. Thus, Lukoil transports the oil produced in the Arkhangelsk oblast via the Varandey and East-Kolguev terminals.

The company Gazprom Neft plans to transport the oil produced in the Novoportovskoe field to Europe by sea through a terminal that is to be built by the end of 2015 in the Gulf of Ob at Cape Kamenniy. A 100-kilometer-long pipeline will be constructed from the oil field to the terminal. The capacity of the transport complex will be 8.5 million tons oil a year.

Marine transportation will also be used to deliver oil from the Prirazlomnoe field in the Pechora Sea.

The largest project is implemented by the oil company Novatek. To transport gas and condensate from the South Tambey field, the company is now constructing the Yamal SPG plant for gas liquefaction on the shore of the Gulf of Ob and the port of Sabetta. It is planned to use this port to organize the transport of gas, crude oil, and gas condensate along the Northern Sea Route to Western Europe, North and South America, and to the Asia–Pacific region. The projected construction period is 2012–2017. An international airport is being built near the plant and the sea port. It will accommodate all types of aircraft including heavy transport planes.

According to the project, it is planned to build a railroad to Sabetta.

The Northern Sea Route will be used to transport hydrocarbons from the lower reaches of the Yenisei river via the Dudinka port and also from the regions in the lower reaches of the Lena river via the Tiksi port.

There is a need for a government program for the development of the Northern Sea Route and creation of the port infrastructure and the Russian fleet of new-generation icebreakers.

Stages in the development of unique hydrocarbon resources in the waters of the Arctic Ocean

Some Russian and foreign mass media call for the suspension of offshore works on the shelves of the Arctic Ocean for the following reasons.

First. Russia has enough carbon resources. Why should the country invest in the Arctic?

Second. Skeptics claim that the gas and especially oil reserves in the Arctic are grossly overestimated and that Russia's Arctic shelf will be unable to provide a long-term supply of hydrocarbons. I would like to recall that the same clich s were used in the 1950s and even 1970s to discredit the West-Siberian project...

Third. It is argued that due to the sanctions there is a significant decrease in financing, there are no advanced domestic technologies for Arctic offshore drilling and hydrocarbon transportation, and West European and American companies are abandoning the Arctic projects.

I believe that these are the opinions of people who are insufficiently informed or misinformed about the history and practice of developing new oil and gas provinces.

Let me reiterate the well-known facts: it takes many years and even decades to prepare a new oil and gas province. The search for oil in West Siberia was initiated in the 1930s and resumed after World War II; the extraction of oil began in the mid-1960s, and the production of Arctic gas, in the early 1970s. The conditions of the Arctic Ocean are even more difficult for development, which will lead to a longer preparation period. If we fail to create the necessary infrastructure, technology, and equipment in advance, we will not be able to start the development when we really need it. Practice shows that post-Soviet Russians tend to overlook the factor of time and the projected cost estimates...

Even after World War II, the country found money to rebuild the economy and invested in the prospecting and exploration of oil and gas in many regions, search for diamonds, implementation of nuclear and space projects, construction of hydroelectric power stations, etc. Can it be that today the situation is worse and our economy is weaker than in 1945–1948?

There have always been sanctions against our country.

No one in the world now has the equipment and technology for oil prospecting and production in the conditions of multiyear ice. These technologies must be created, and this is the job of researchers and engineers. This does not rule out the prospects of cooperation with other countries, but it must be interaction rather than unilateral dependence.

It has been shown above that since the 1930s the Soviet Union/Russia have been pioneers in the development of the Arctic and its mineral resources. There are numerous impressive examples illustrating the potential of the Russian science and Russian industry. Here are some of them.

Example 1. A convincing proof of our capabilities and our capacity to create breakthrough technologies for the development of the Arctic is Russia's nuclear-powered icebreaker fleet. Let me tell you the story behind this brilliant project. The resolution to build the world's first

The Prirazlomnoe field. Pechora Sea, April 2014.
© Gazprom Neft, 2015

nuclear-powered icebreaker *Lenin* was adopted by the USSR Council of Ministers at the proposal of the RAS Members I. V. Kurchatov and A. P. Aleksandrov as of November 20, 1953. The nuclear-powered icebreaker *Lenin* was designed by Central Design Bureau 15 (now the company Aisberg) in 1953–1955. V. I. Neganov was appointed the chief designer of the project; I. I. Afrikantov was the project manager of the nuclear installation; and A. P. Aleksandrov was the scientific supervisor of the project. The institute Prometei developed special grades of steel for the hull of the icebreaker. The construction of the icebreaker *Lenin* was completed in 1959. It took only six years to bring the project from an idea to the completion.

The experience of the construction and operation of the icebreaker *Lenin* was use to design the following icebreakers: Arktika (1975), Sibir (1978), Rossiya (1985), Sevmorput (1988), Sovetskii Soyuz (1989), Taimyr (1989), Vaigach (1990), Yamal (1993), and 50 Let Pobedy (2007). The nuclear icebreaker fleet is indispensable for the development of Arctic areas with year-round ice cover and for the development and year-round use of the Northern Sea Route. Most of the ships of the nuclear icebreaker fleet were built at the Baltic Shipyard in Leningrad.

Example 2. No less compelling though more recent evidence of Russia's technological capabilities is the creation of the offshore ice-resistant stationary oil-producing platform (OIRSOPP) Prirazlomnaya, which was constructed by Sevmash Production Association.

The platform is specially designed for the development of oil fields. It provides for the implementation of all necessary technological operations, i. e.,

- drilling of production and injection wells;
- extraction of oil and associated gas, water injection;
- preparation of extracted oil and gas;
- temporary storage of tank oil; and
- offloading of tank oil into shuttle tankers.

In accordance with the terms and conditions of work on the Arctic shelf, the platform Prirazlomnaya allows the extraction of hydrocarbons on the Arctic shelf from a stationary platform in the difficult conditions of drifting ice flows. The platform is designed for operation in extreme climatic conditions; it meets the most stringent safety requirements and is able to withstand the maximum ice loads. The structural elements of the platform that protect it from the impact of waves and moving ice, low temperatures, and high humidity use special steels, alloys, coatings, and systems of cathodic and anodic shields.

The platform is equipped with a system that guarantees safe conditions for the implementation of production processes and for the work and recreation of the engineers and workers. There are also recovery facilities and life-saving equipment for people on the platform.

The platform ensures complete environment safety of the operations and maintenance. It provides for the storage of all industrial and domestic waste in special containers and for their transportation to shore for disposal in accordance with applicable environmental requirements.

The platform is characterized by long-term self-sustainability thus ensuring year-round operability.

This is the world's first platform of this kind.

The creation of offshore ice-resistant stationary oil-producing platform Prirazlomnaya is a great success of Gazprom, Sevmash Production Association, and personally the RAS Member E. P. Velikhov, who initiated this project.

Example 3. In the Yarega oil field, Lukoil has been the world's first company to implement the project of counter (reverse) thermal gravity drainage, which is expected to increase the heavy oils recovery at the Yarega oil field by up to 70–85%.

Impressive examples of innovation, development, and introduction of new technologies have been demonstrated by Novatek and Gazprom Neft on the Yamal Peninsula.

Other such examples are needed—in the form of completed projects rather than bright illustrations.

As has already been mentioned, Russia as well as the mankind as a whole will really need the Arctic hydrocarbons in the second half of the 21st century.

I believe the following steps should be taken to achieve this goal:

2015—2030. Onshore works are to be continued. Regional offshore works are to be carried out in the seas of the Arctic Ocean. Priority projects should be selected. Prospecting works must be performed wherever it is possible, using available technologies and equipment.

It is necessary to perform large-scale scientific research aimed at the creation of equipment and technologies for prospecting, exploration, and development of hydrocarbon deposits on the Arctic shelves, in the year-round ice zones, etc. Clearly, the equipment and technologies should meet the most stringent environmental requirements. A comprehensive work program should be prepared and implemented, and I am sure that RAS is ready for such a challenging task.

2030—2040. Testing, necessary adjustment, and refining of the equipment, technologies, prospecting, and development of hydrocarbon deposits in the year-round ice zones, etc. Organization of prospecting in priority areas.

2040—2050. Creating raw material bases for new centers for extraction, preparation, and transportation of oil and gas. Development of the necessary infrastructure.

If we slow down the implementation of at least one of these steps... we will lose the Arctic. And this may also lead to the loss of national security...

Here I fully agree with Vladimir Putin, who said in his Address to the Federal Assembly on December 4, 2014: "The period ahead will be complex and difficult, when much will depend on what each of us does at his workplace. The so-called sanctions and foreign restrictions are an incentive for a more efficient and faster movement towards our goals. We need to do much. We need to create new technologies, a competitive environment, and an additional margin of strength in the industry, the financial system, and in the advanced training of personnel. This is possible as we have a large domestic market and natural resources, capital and research projects. We also have talented, intelligent, and hard-working people who can learn very quickly."

Since the times of the first Arctic expeditions, we have that this region only submits to strong, purposeful, and courageous people who pursue their goal against all odds. Over the most part of the 20th century, our country had been a pioneer and an undisputed leader in the Arctic exploration. And it must keep up its Arctic efforts in the future. I do not believe that the 25 years during which the Russian economy has been developing by the design of liberal reformers, according to which everything, including brains, can be bought for petrodollars, has completely destroyed the best qualities of the Russian nation and its creativity.

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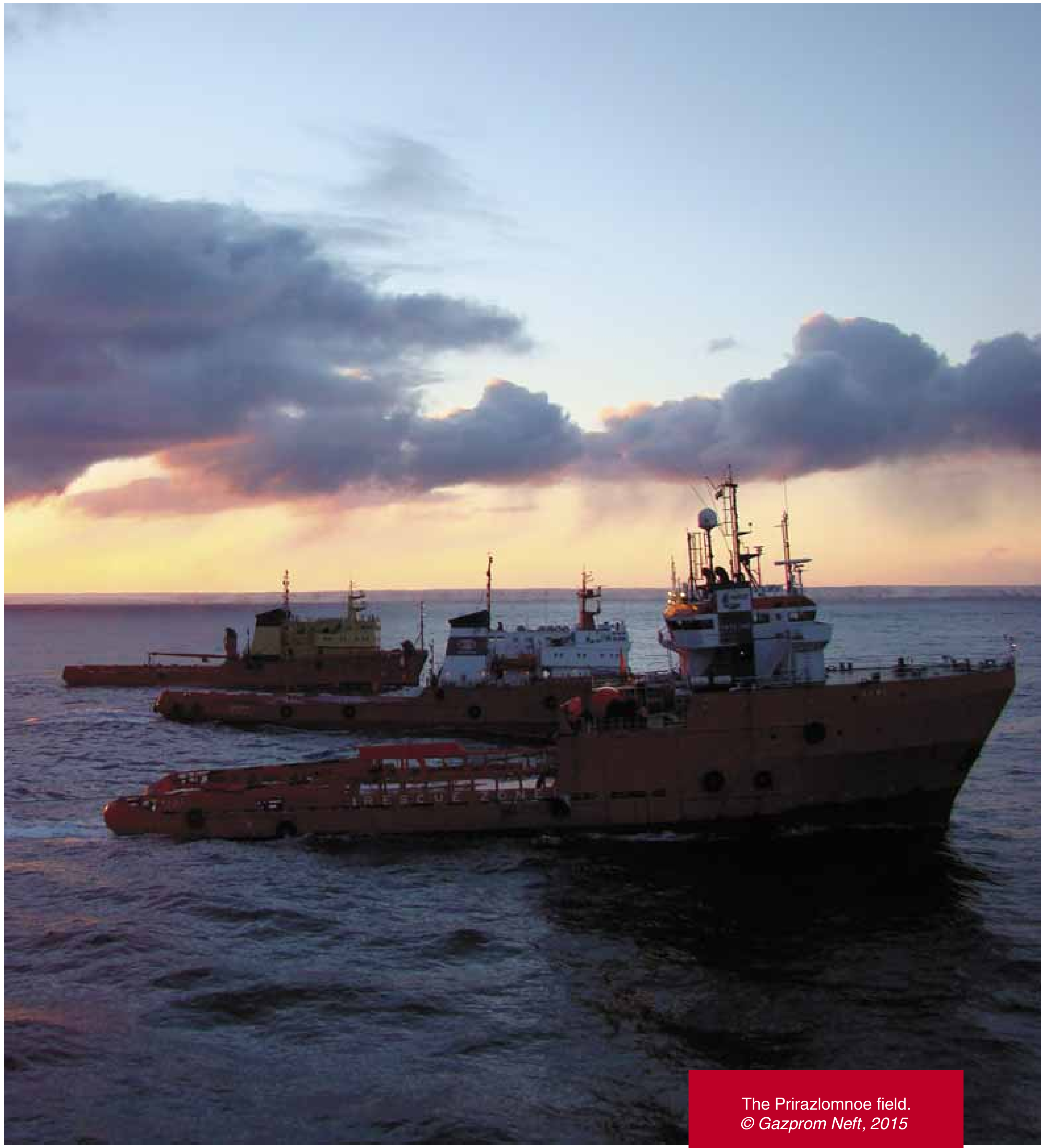

The Prirazlomnoe field.
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